Forecourt Team Overview

Stephen Lasher, TIAX LLC - Delivered LH_2, cH_2
Brian James, DTI - NG Reformer, Electrolyser
Matt Ringer, NREL - MeOH, Ethanol Reformer, spreadsheet development

NHA Conference

4/28/04

Renaissance Hollywood Hotel, Los Angeles CA

Forecourt Station Capacities

Type of Station	Design Capacity	Average Fuel Demand	Average Cars Refueled
Small H_2 Capacity	100 kg H_2/day	70 kg H_2/day	12 H_2 cars/day
Large H_2 Capacity	1,500 kg H_2/day	1,050 kg H_2/day	175 H_2 cars/day
Average Gasoline Station	-	3,000 gal/day	375 conventional cars/day

Note: Assumes 70% capacity factor and 6 kg/fill for H_2 capacity, and 8 gallons gasoline per fill on average.

- Small and large H_2 capacities are assumed to be integrated into existing gasoline stations with 8 dispensers total
  - Small station = 1 cH_2 dispenser
  - Large station = 3 cH_2 dispensers

Summary of Cases

Type of Station	Small	Large	Current Technology / Design Assumptions
Delivered LH_2 Tanker Truck	X	X	LH_2 primary storage, 6250 psi LH_2 cryo-pump and evaporator + cascade dispensing
Delivered cH_2 Tube Trailer	X		Tube Trailer primary storage, 6250 psi compression + cascade dispensing
Delivered cH_2 Pipeline		X	No primary storage, 6250 psi compression + cascade dispensing
Natural Gas Reformer	X	X	SR with PSA cleanup, 6250 psi compression, cascade storage/dispensing
Methanol Reformer	Fall '04	Fall '04	TBD
Ethanol Reformer	Fall '04	Fall '04	TBD
Electrolyser	X	X	Alkaline electrolyser, 6250 psi compression, cascade storage/dispensing

Note: All cases include assessment of current, mid-term, and long-term technologies.

Summary of Cases: Technology Parameters - Large H_2 Capacity

Equipment	Current	Mid-term	Long-term
LH_2 Storage	No boil-off recovery: 0.4%/day losses	Boil-off recovery: 0.2%/day losses	Boil-off recovery: 0.0%/day losses
cH_2 Storage	Steel tanks: $818/kg$_{H2\ stored}$	Composite tanks: $323/kg$_{H2\ stored}$	Composite tanks: $296/kg$_{H2\ stored}$
cH_2 Compression	Recip-piston type: 65% ad. efficiency	Intensifier or other?: 75% ad. efficiency	Advanced?: 85% ad. efficiency
NG-based H_2 Production Unit	SR with PSA: 10 year life 69% LHV efficiency $1.2 MM (uninstalled)	Adv. Reformer and separation: 15 year life 72% LHV efficiency $0.90 MM (uninstalled)	Compact and combined steps: 20 yr life 73% LHV eff. $0.82 MM (uninstalled)
Electrolyser	Alkaline: 64% LHV efficiency $665/kW$_{input}$	Alkaline or PEM: 71% LHV efficiency $400/kW$_{input}$	Adv. Alkaline/PEM: 76% LHV efficiency $300/kW$_{input}$

Note: Sensitivity analysis lower/upper bounds incorporate affects of other technologies.

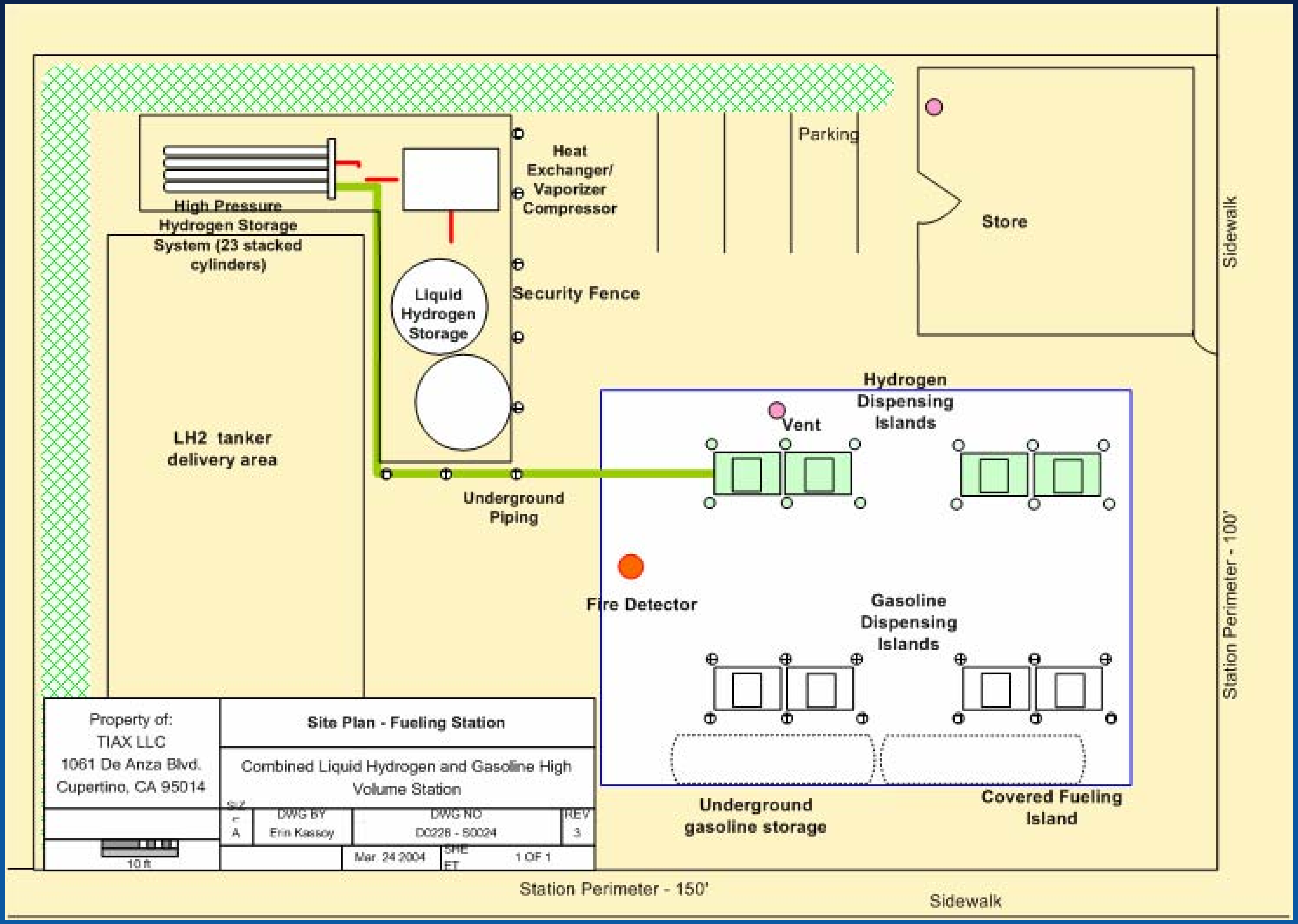
Common Forecourt Assumptions (1)

- Assume “brown field” expansion of existing gasoline stations
- Divide common station operating costs based on hydrogen / gasoline / non-fuel sales
  - Station operator labor
  - Overhead and G&A
  - Other variable operating costs
- Land is rented at $0.50/ft^2 per month
- “Nth Plant” assumption, i.e., 500 stations installed per year
- 20 year analysis period and plant life
  - Replacements according to equipment life
- Commercial utility rates for most cases
  - Industrial electricity and NG for large electrolyser and NG reformer

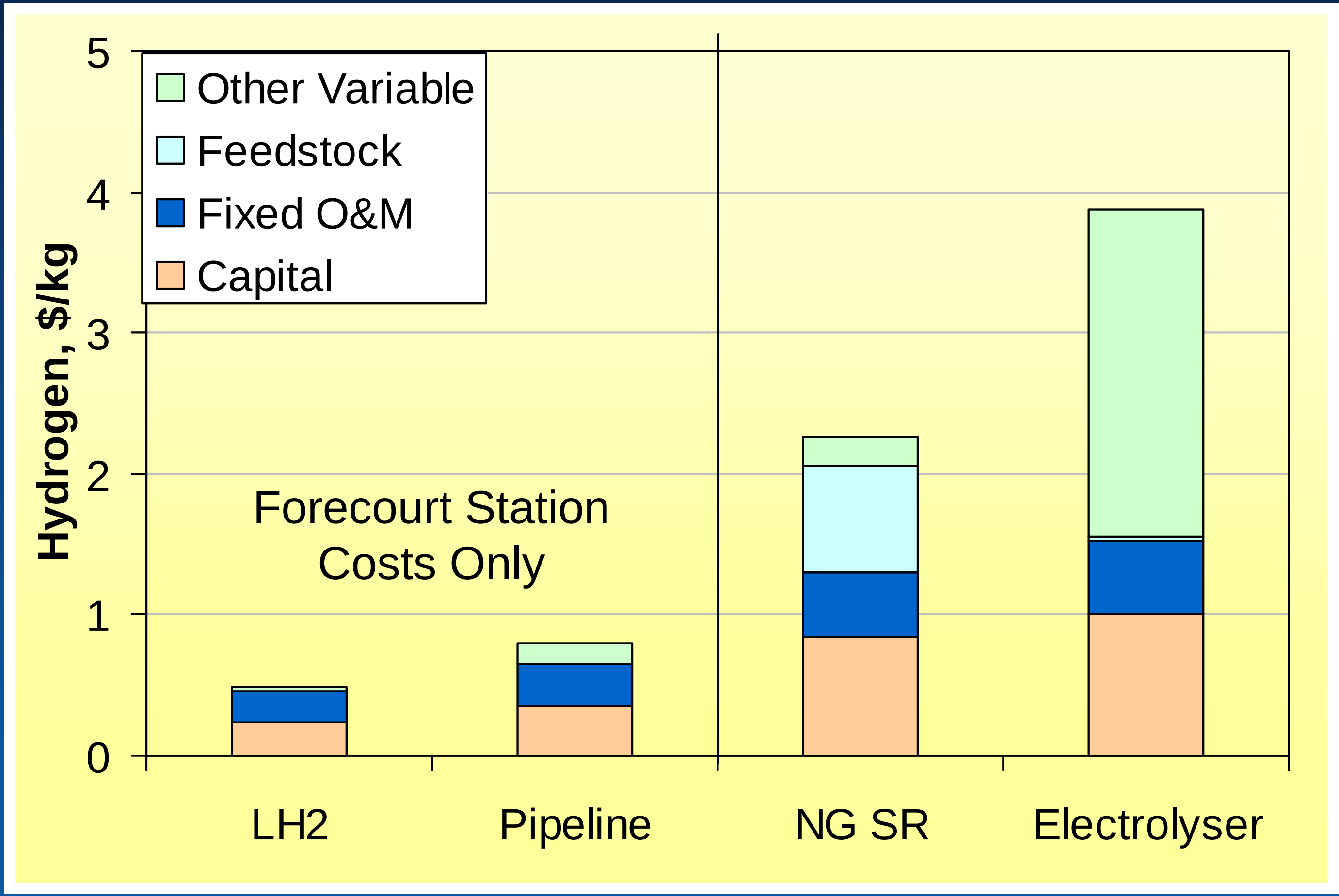
Common Forecourt Assumptions (2)

- 70% station capacity factor
  - 10% weekday to weekend surge factor * 20% seasonal surge factor * 3% for scheduled downtime
- 6,250 psi dispensing compressed gaseous hydrogen
  - 5,000 psi on-board vehicle storage
- Storage and dispenser requirements based on assumed vehicle and hydrogen demands
  - 2 daily peaks
  - 40% of total daily throughput in 3-hours
  - 6 kg/fill per vehicle with simultaneous fills
- Overall safety and controls equipment costs are included
  - Fire detector, intrinsically safe wiring, hydrogen sensors, alarms, data acquisition, controls, etc.

Generic Site Plans

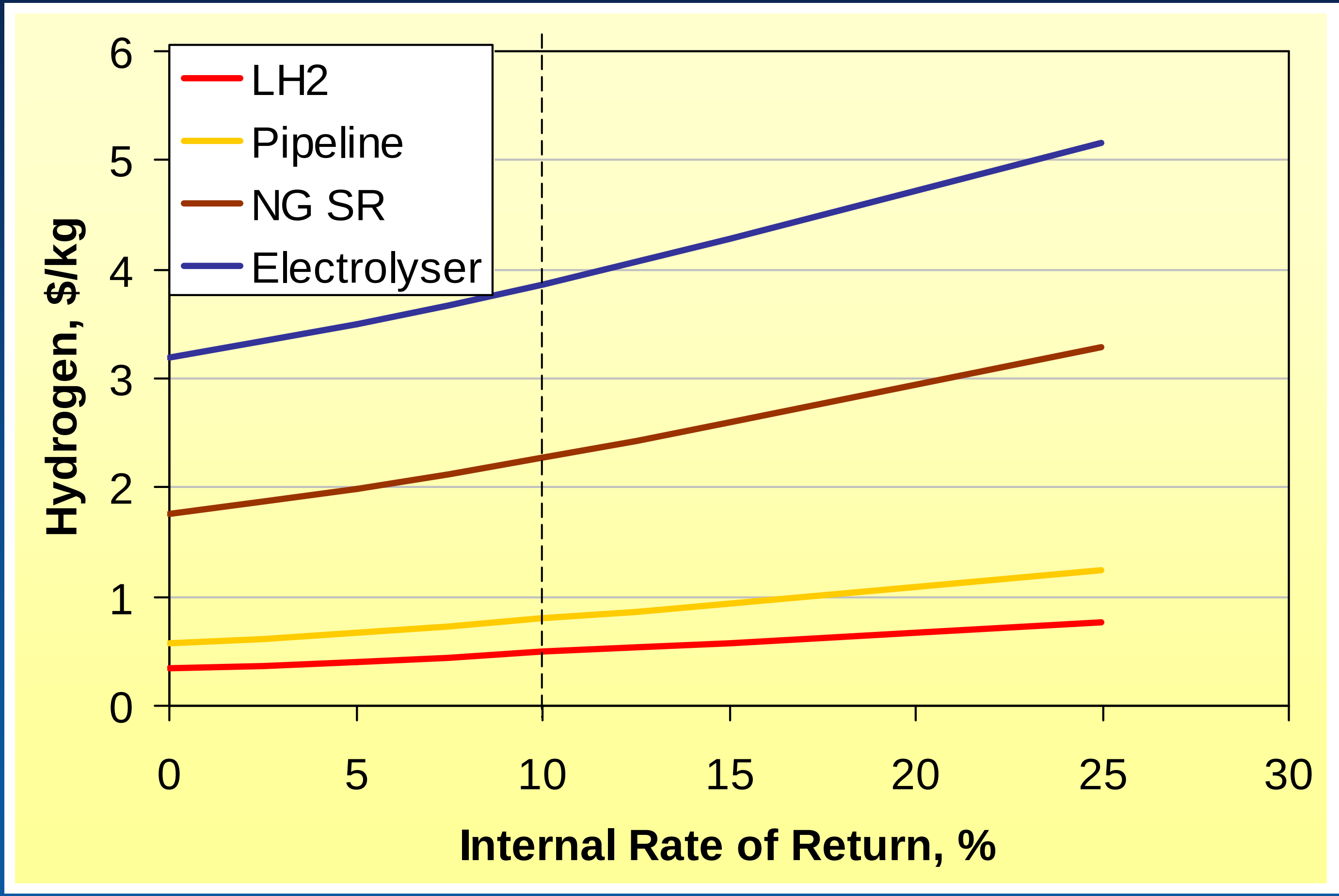


Base Case Results: Mid-term Technology - Large H_2 Capacity



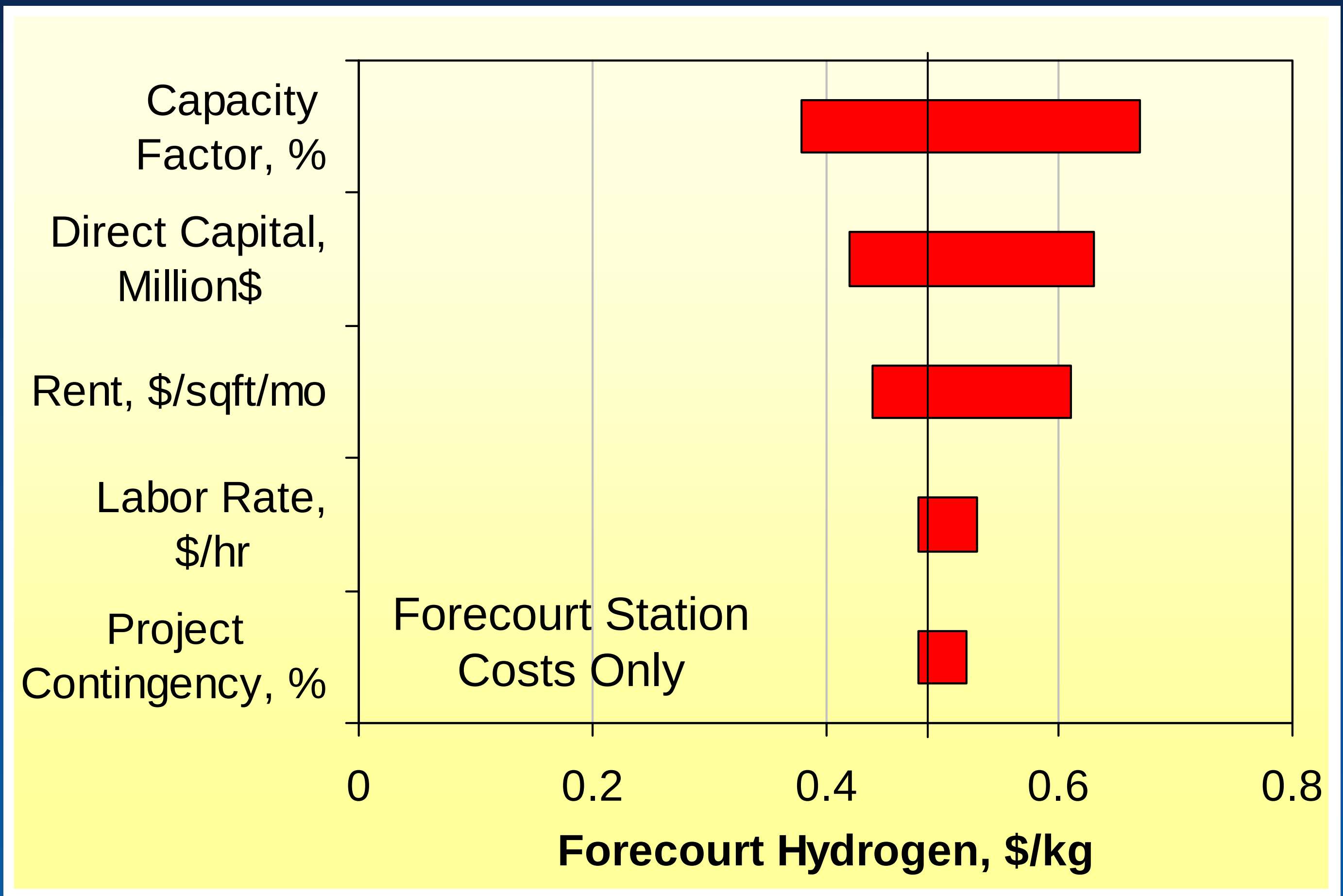
Note: For side by side comparison, central plant and delivery costs must be added to the Pipeline and LH_2 cases.

IRR Sensitivity Results: Mid-term Technology - Large H_2 Capacity



Note: For side by side comparison, central plant and delivery costs must be added to the Pipeline and LH_2 cases.

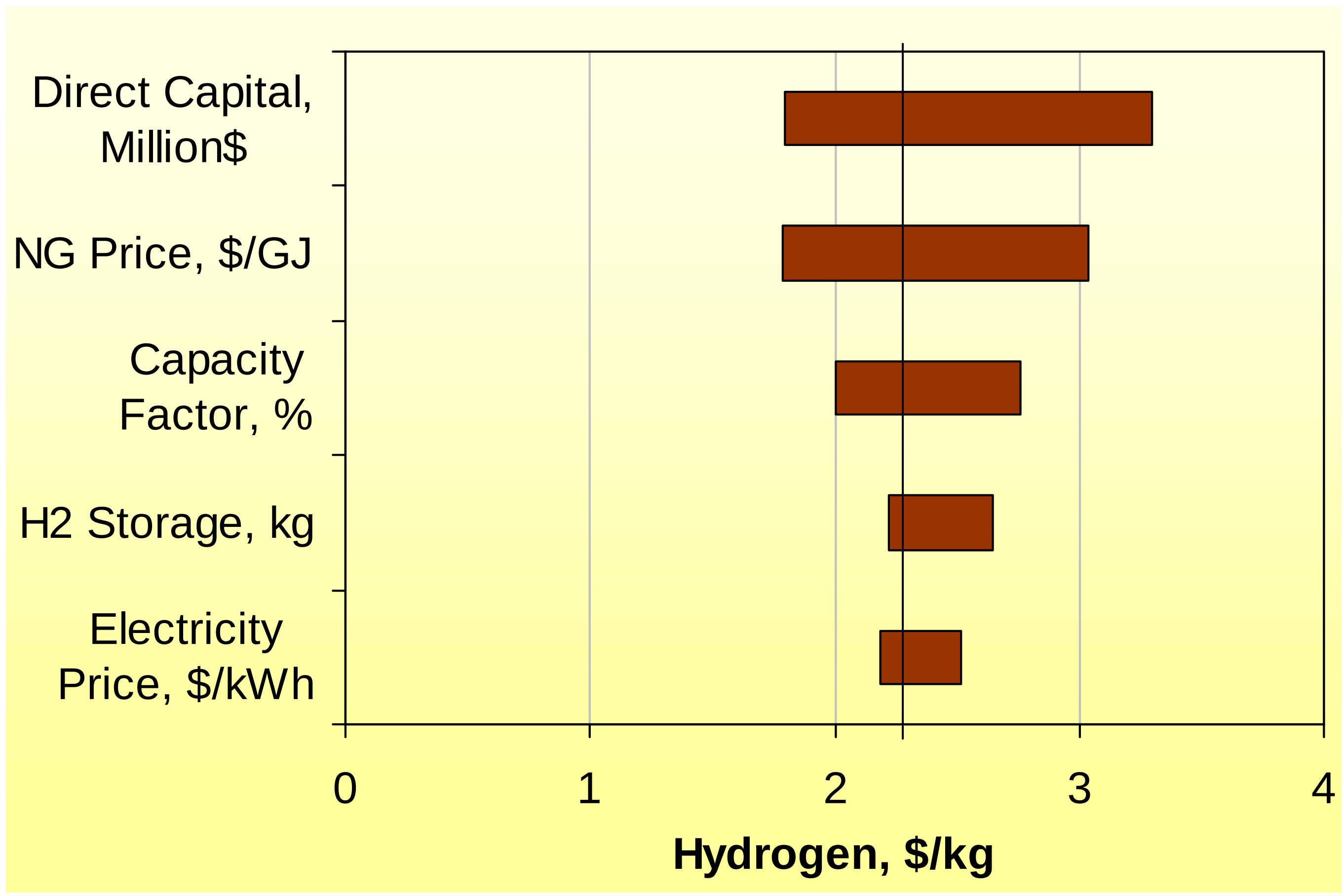
Sensitivity Results: Mid-term Technology - Large LH_2



Low	Base	High
90	70	50
0.30	0.45	0.75
0.30	0.50	1.0
12	15	25
5	10	30

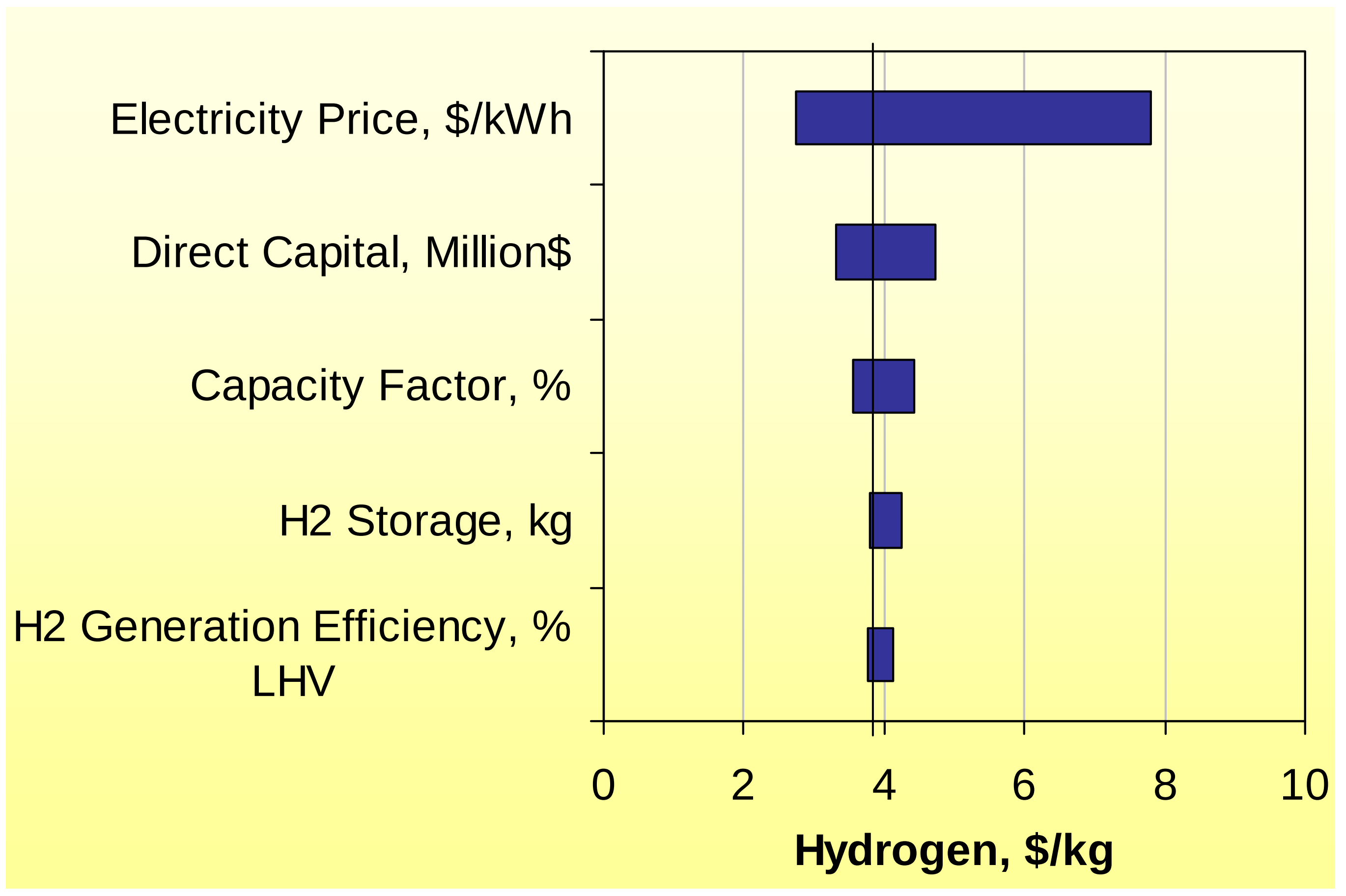
Note: For side by side comparison with the on-site production options, central plant and delivery costs must be added to the LH_2 case.

Sensitivity Results: Mid-term Technology - Large NG SR



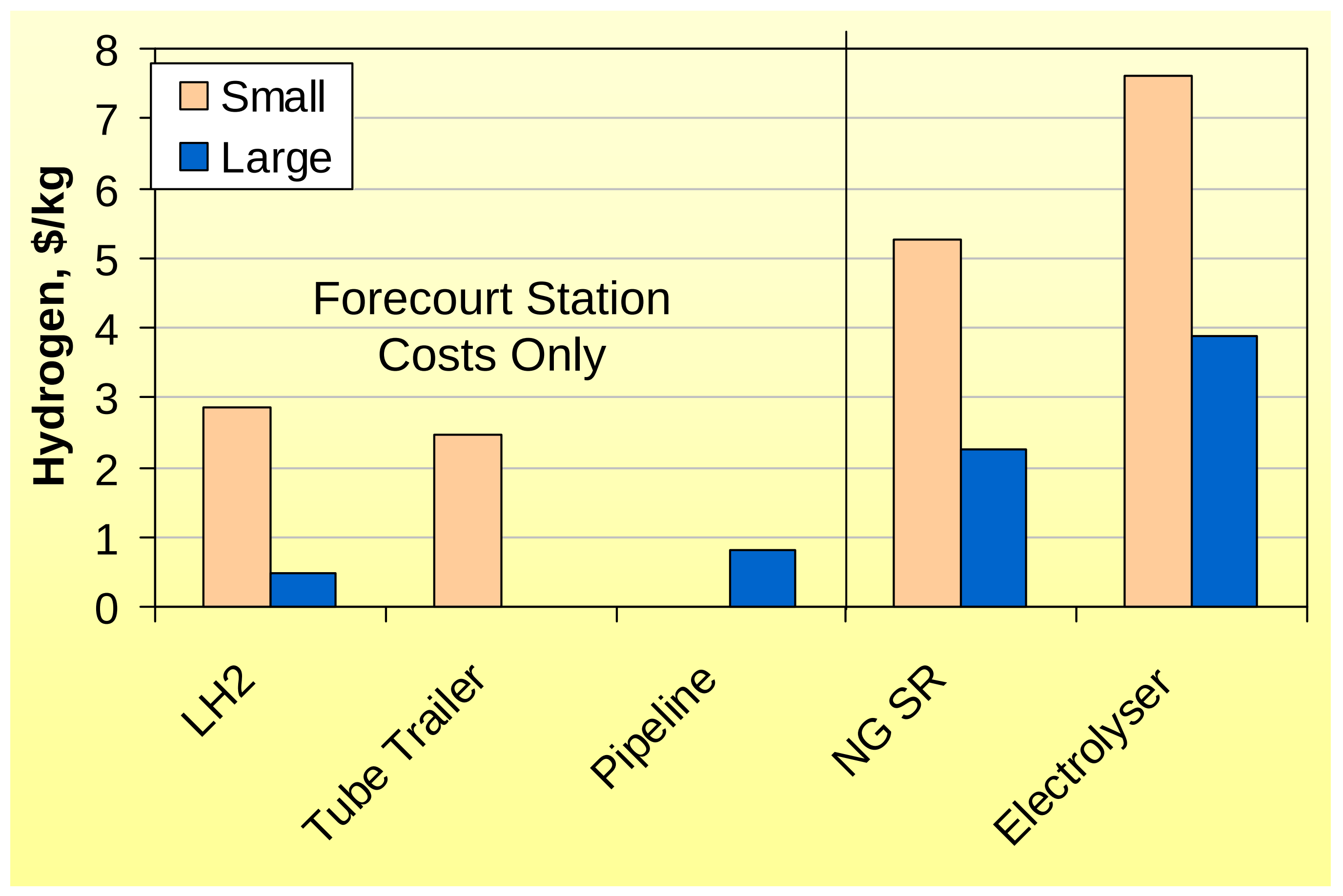
Low	Base	High
0.9	1.8	3.1
1.85	~4.15	8.58
90	70	50
375	525	1,500
0.025	~0.048	0.12

Sensitivity Results: Mid-term Technology - Large Electrolyser



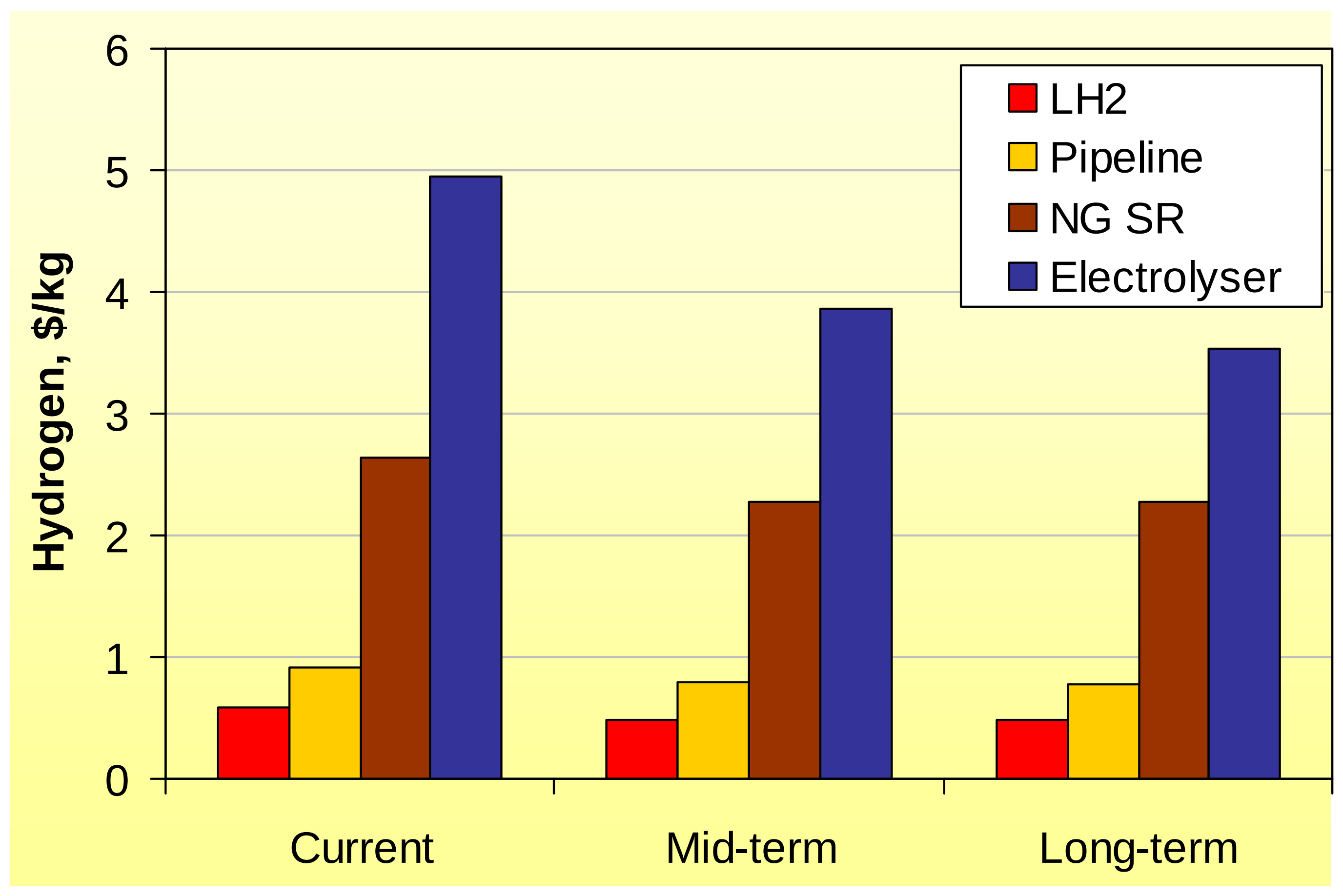
Low	Base	High
0.025	~0.048	0.12
1.1	2.2	3.7
90	70	50
375	525	1,500
74	71	64

Base Case Results: Mid-term Technology - Large Vs. Small Capacity



Note: For side by side comparison, central plant and delivery costs must be added to the Pipeline, Tube Trailer, and LH_2 cases.

Base Case Results: Technology Improvements - Large H_2 Capacity



Note: For side by side comparison, central plant and delivery costs must be added to the Pipeline and LH_2 cases.

What We Have Done

- Developed forecourt standard reporting spreadsheet (SRS)
  - Documents design and cost input assumptions and results
  - Consistent with Central SRS
- Completed base cases for large and small capacities with sensitivity analysis for current, mid-term, and long-term technologies
  - LH_2 and cH_2 (Tube Trailer and Pipeline) Delivery
  - NG Reformer
  - Electrolyser

Next Steps

- Integrate Central and Delivery Team results into relevant cases (Fall ’04)
  - cH_2 delivery via Tube Trailer and Pipeline
  - LH_2 delivery via Tanker Truck
- Complete remaining on-site production cases (Fall ‘04)
  - MeOH Reformer
  - Ethanol Reformer
- Continue discussions with KIC and other industry representatives (ongoing iterative process)
  - Refine design and cost assumptions if necessary
  - Refine results if necessary

Thank You

- KIC
- DOE
- Colleagues at TIAX, DTI, and NREL
- Audience